AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the above-identified application:

1. (Original) A method of analyzing a turbine engine to determine a normal engine condition or a faulty engine condition, said method comprising the steps of:

acquiring at least one engine operating parameter;

calculating at least one engine residual value from said at least one engine operating parameter;

normalizing said at least one engine residual value to yield at least one normalized engine residual;

mapping, via a clustering technique, said at least one normalized engine residual as at least one input vector into an engine condition space having a plurality of clusters, each of said plurality of clusters representing either a normal vector engine condition or a faulty vector engine condition;

identifying a closest cluster within said engine condition space, said closest cluster being closer to said at least one input vector than any other of said plurality of clusters; and

determining a normal engine condition for the engine undergoing analysis if said closest cluster represents a normal vector engine condition, and determining a faulty engine condition for the engine undergoing analysis if said closest cluster represents a faulty vector engine condition.

2. (Original) The method of claim 1 wherein said engine operating parameter is selected from the group consisting of: core speed, exhausted gas temperature, and fuel flow.

3. (Original) The method of claim 1 wherein said step of acquiring at least one engine operating parameter comprises the step of collecting engine operating data in the field.

4. (Original) The method of claim 1 wherein said step of calculating said at least one engine residual value comprises the step of comparing said at least one engine operating parameter with standard engine characteristics obtained from an empirical engine model.

5. (Original) The method of claim 4 wherein said empirical engine model comprises a polynomial function of engine fan speed.

6. (Original) The method of claim 4 wherein said empirical engine model comprises a neural network.

7. (Original) The method of claim 1 wherein said step of calculating said at least one engine residual value comprises the step of comparing said at least one engine operating parameter with standard engine characteristics obtained from a first principle engine model.

8. (Original) The method of claim 7 wherein said first principle engine model comprises a differential equation representing dynamics of the turbine engine.

9. (Original) The method of claim 1 wherein said step of normalizing comprises the step of normalizing a mean of said at least one engine residual value to zero.

10. (Original) The method of claim 1 wherein said step of normalizing comprises the step of normalizing a standard derivation of said at least one engine residual value to unity.

11. (Original) The method of claim 1 wherein said step of normalizing comprises the step of obtaining a normalization factor from a parameter distribution of a normally-operating baseline engine.

12. (Original) The method of claim 11 further comprising the step of deriving an updated normalization factor if said closest cluster represents a normal vector engine condition.

13. (Original) The method of claim 12 wherein said step of deriving an updated normalization factor comprises the steps of multiplying the square of a current mean normalization factor by a first fraction to obtain a first product; obtaining a current engine parameter from the turbine engine; multiplying said current engine parameter by a second fraction to obtain a second product; and adding said first and second products to yield an updated mean normalization factor.

14. (Original) The method of claim 12 wherein said step of deriving an updated normalization factor comprises the steps of multiplying the square of a current standard deviation normalization factor by a first fraction to obtain a first product; subtracting an

updated mean normalization factor from said current engine parameter to obtain a first difference; multiplying the square of said first difference by a second fraction to obtain a second product; subtracting a current mean normalization factor from said current engine parameter to obtain a second difference; multiplying the square of said second difference by a third fraction to obtain a third product; and, taking the square root of said first, second, and third products to yield an updated standard deviation normalization factor.

15. (Original) The method of claim 1 wherein said clustering technique mapping comprises a self-organizing map.

16. (Original) The method of claim 15 further comprising the step of training said self-organizing map for a plurality of epochs using data from a plurality of turbine engines.

17. (Original) The method of claim 1 wherein said clustering technique mapping comprises a method from the group consisting of fuzzy clustering, adaptive resonance theory, K-means algorithm, and Gaussian mixture method.

18. (Original) The method of claim 1 further comprising the step of deriving a belief factor, said belief factor being a function of said normal vector engine condition or said faulty vector engine condition.

19. (Original) The method of claim 18 wherein, when said faulty engine condition is determined for the turbine engine, said belief factor comprises a value derived by subtracting from unity a ratio obtained by dividing a closest distance between said at least

one input vector and said closest cluster by a next-closest distance between said at least one input vector and a next closest cluster.

20. (Original) The method of claim 18 wherein, when said normal engine condition is determined for the turbine engine, said belief factor comprises a value derived by subtracting from unity a maximum ratio of the set of ratios obtained by dividing a distance between said at least one input vector and said closest cluster by each of a set of respective fault distances between said at least one input vector and all clusters representing a faulty vector engine condition.

21. (Original) The method of claim 1 wherein said faulty engine condition is selected from the group consisting of: an exhaust temperature sensor failure, a combustor liner burn-through failure, and a bleed band leakage failure.

22. (Currently Amended) A computer readable medium having computer-executable instructions comprising ~~for performing a method, wherein said method comprises~~:

calculating at least one engine residual parameter from data generated from a engine model and from engine operating data collected in the field from an engine undergoing analysis;

normalizing said at least one engine residual value to yield at least one normalized engine residual;

mapping via a clustering technique said at least one normalized engine residual as at least one input vector into an engine condition space having plurality of clusters, each of said plurality of clusters representing either a normal vector engine condition or a faulty vector engine condition;

identifying a closest cluster within said engine condition space, said closest cluster being closer to said at least one input vector than any other of said plurality of clusters; and

determining a normal engine condition for the engine undergoing analysis if said closest cluster represents a normal vector engine condition, and determining a faulty engine condition for the engine undergoing analysis if said closest cluster represents a faulty vector engine condition.

23. (Currently Amended) The computer readable medium of claim 22 wherein said clustering technique mapping comprises ~~a method~~ <u>a mapping</u> from the group consisting of self-organizing mapping, fuzzy clustering, adaptive resonance theory, K-means algorithm, and Gaussian mixture method.

24. (Currently Amended) The computer readable medium of claim 22 wherein ~~said method further comprises inputting into the computer~~ engine operating data collected in the field <u>are inputted into the computer</u>.

25. (Currently Amended) The computer readable medium of claim 22 wherein ~~said method further comprises inputting into the computer~~ standard engine characteristics obtained from said engine model <u>are inputted into the computer</u>.

26. (Currently Amended) The computer readable medium of claim 22 wherein ~~said method further comprises inputting into the computer~~ normalization factors obtained from a normally-operating baseline engine <u>are inputted into the computer</u>.

27. (Currently Amended) The computer readable medium of claim 22 wherein ~~said method further comprises calculating~~ a closest distance between said at least one input vector and said closest cluster is calculated.

28. (Currently Amended) The computer readable medium of claim 27 wherein ~~said method further comprises calculating~~ a belief factor is calculated, in response to a determination of said faulty engine condition, by dividing said closest distance by a next-closest distance between said at least one input vectors and a next closest cluster and subtracting the result from unity.

29. (Currently Amended) The computer readable medium of claim 27 wherein ~~said method further comprises calculating~~ a belief factor is calculated, in response to a determination that the engine condition is normal, by subtracting from unity a maximum ratio from the set of ratios obtained by dividing said closest distance by each of a set of respective fault distances between said input vectors and the set of all clusters representing a faulty condition.

30. (Currently Amended) The computer readable medium of claim 27 wherein ~~said method further comprises inputting~~ data from a plurality of turbine engines is inputted into said self-organizing map to train said self-organizing map.

31. (Original) A method of analyzing a turbine engine to determine a normal engine condition or a faulty engine condition, said method comprising the steps of:

acquiring a plurality of engine operating parameters from the turbine engine under analysis;

calculating a corresponding plurality of engine residual values by comparing each of said engine operating parameters with standard engine characteristics obtained from an engine model;

computing the mean and the standard deviation of each of said plurality of engine residual values;

normalizing each of said plurality of engine residual values by normalizing said mean to zero and by normalizing said standard deviation to unity to yield a plurality of normalized engine residuals, said step of normalizing using normalization factors obtained from a parameter distribution of a normally-operating baseline engine;

mapping, via a clustering technique, said normalized engine residuals as input vectors into an engine condition space having a plurality of clusters, each said cluster representing either a normal vector engine condition or a faulty engine vector condition;

identifying a closest cluster within said engine condition space, said closest cluster being closer to said input vectors than any other of said plurality of clusters; and

determining a normal engine condition for the engine under analysis if said closest cluster represents a normal vector engine condition, and determining a faulty engine condition for the engine under analysis if said closest cluster represents a faulty vector engine condition.

32. (Original) The method of claim 31 wherein said plurality of engine operating parameters comprises a core speed measurement, an exhausted gas temperature measurement, and a fuel flow measurement.

33. (Original) The method of claim 31 wherein said clustering technique mapping comprises a method from the group consisting of self-organizing mapping, fuzzy clustering, adaptive resonance theory, K-means algorithm, and Gaussian mixture method.

34. (Original) The method of claim 31 further comprising the step of deriving a belief factor wherein, if turbine engine condition is determined to be faulty, said belief factor comprises a value derived by subtracting from unity a ratio obtained by dividing a distance between said input vectors and said closest cluster by a distance between said input vectors and a next closest cluster, and wherein, if said engine is determined to be normal, said belief factor comprises a value derived by subtracting from unity a maximum ratio of the set of ratios obtained by dividing a distance between said input vectors and said closest cluster by each of the set of fault distances between said input vectors and all clusters representing a faulty condition.

35. (Original) A method of analyzing a turbine engine to determine a normal engine condition or a faulty engine condition, said method comprising the steps of:

inputting data into a self-organizing map from a plurality of reference turbine engines to train said self-organizing map;

acquiring a core speed reading, an exhaust gas temperature reading, and a fuel flow reading for the turbine engine under analysis;

calculating a core speed residual value, an exhaust gas temperature residual value, and a fuel flow residual value by comparing said core speed reading, said exhaust gas temperature reading, and said fuel flow reading with corresponding standard engine characteristics obtained from an engine model;

computing the mean and the standard deviation of each of said core speed residual value, said exhaust gas temperature residual value, and said fuel flow residual value;

normalizing each of said core speed residual value, said exhaust gas temperature residual value, and said fuel flow residual value by normalizing said respective means to zero and by normalizing said standard deviation to unity to yield a normalized core speed residual, a normalized exhaust gas temperature residual, and a normalized fuel flow

residual, said step of normalizing using normalization factors obtained from a parameter distribution of a normally-operating baseline engine;

mapping, via said self-organizing map, said normalized core speed residual, said normalized exhaust gas temperature residual, and said normalized fuel flow residual as respective input vectors into an engine condition space having a plurality of clusters, each said cluster representing either a normal vector engine condition or a faulty vector engine condition; and

identifying a closest cluster within said engine condition space, said closest cluster being closer to said input vectors than any other of said plurality of clusters; and, determining a normal engine condition for the engine under analysis if said closest cluster represents a normal vector engine condition, and determining a faulty engine condition for the engine under analysis if said closest cluster represents a faulty vector engine condition.

36. (Original) The method of claim 35 further comprising the step of calculating a closest distance between said at least input vectors and said closest cluster.

37. (Original) The method of claim 36 further comprising the step of calculating a belief factor for said faulty engine condition by dividing said closest distance by a next-closest distance between said input vectors and a next closest cluster and subtracting the result from unity.

38. (Original) The method of claim 36 further comprising the step of calculating a belief factor for said normal engine condition by subtracting from unity a maximum ratio from the set of ratios obtained by dividing said closest distance by a fault distance between said input vectors and the set of all clusters representing a faulty condition.

39. (Original) The method of claim 36 further comprising the step of deriving an updated normalization factor if said closest cluster represents a normal vector engine condition, said step of deriving an updated normalization factor including the steps of multiplying the square of a mean normalization factor by a first fraction to obtain a first product, obtaining a current engine parameter from the turbine engine, multiplying said current engine parameter by a second fraction to obtain a second product, and adding said first and second products to yield an updated mean normalization factor.

40. (Original) The method of claim 39 wherein said step of deriving an updated normalization factor further comprises the steps of multiplying the square of a current standard deviation normalization factor by a third fraction to obtain a third product; subtracting said updated mean normalization factor from said current engine parameter to obtain a first difference; multiplying the square of said first difference by a fourth fraction to obtain a fourth product; subtracting said mean normalization factor from said current engine parameter to obtain a second difference; multiplying the square of said second difference by said second fraction to obtain a fifth product; and, taking the square root of the sum of said third, fourth, and fifth products to yield an updated standard deviation normalization factor.